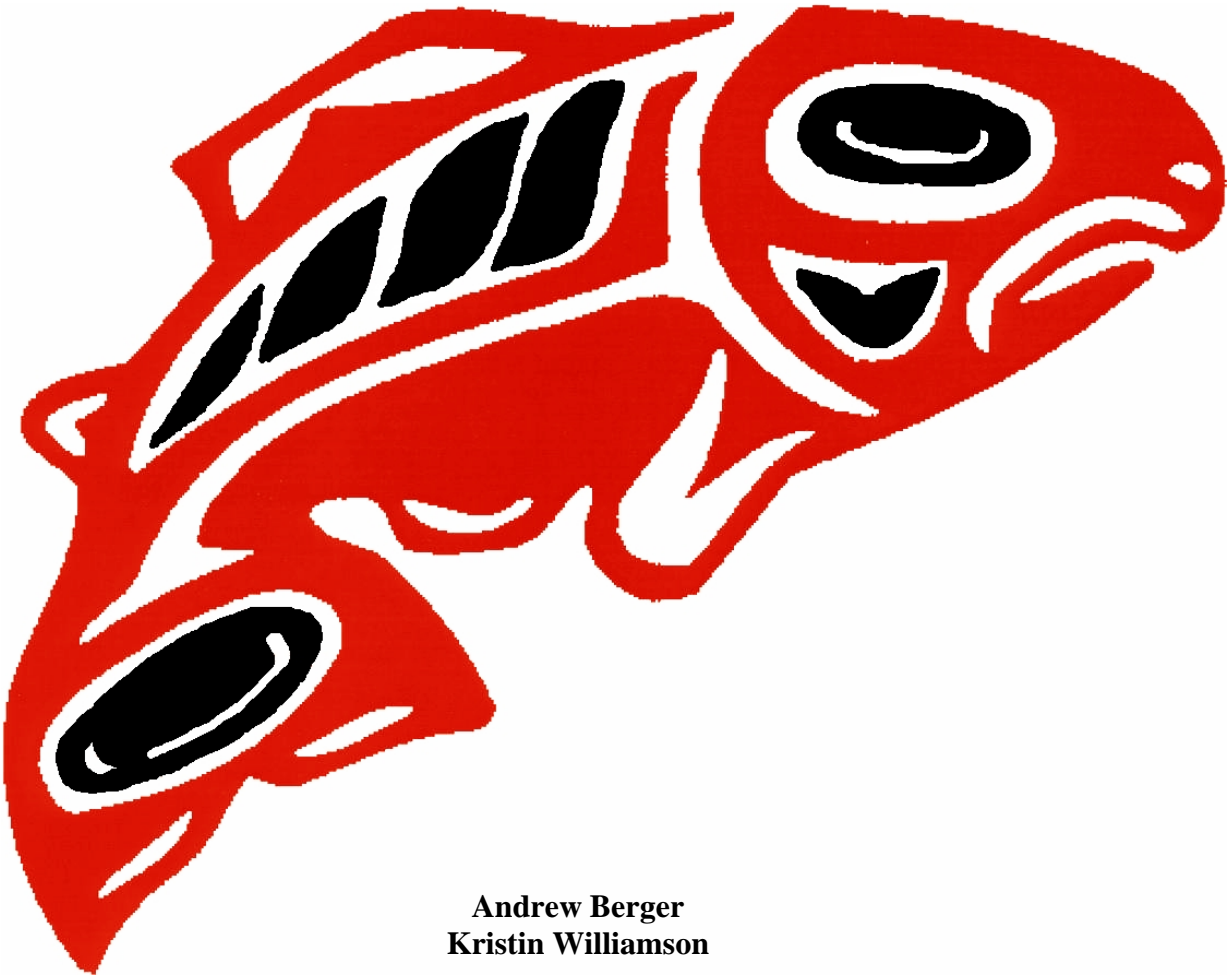# Puyallup River Juvenile Salmonid Production Assessment Project 2004

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Acknowledgments

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INTRODUCTION

The Puyallup River watershed encompasses 438 square miles including three major tributaries: the Carbon River, Mowich River and South Prairie Creek. The Puyallup River flows westward over 54 miles from the southwest slope of Mount Rainier to Commencement Bay, and has an average annual flow of 1,375 cfs near the trap (USGS, 2003). The Puyallup, Carbon and Mowich Rivers originate from glaciers located in Mt. Rainer National Park and exhibit the classic features of glacial streams: frequently shifting braided channels, high turbidity and low temperatures. South Prairie Creek, which is a non-glacial tributary of the Carbon River, is fed by groundwater and seasonal runoff and offers clear water and moderate temperatures. The Puyallup-White River watershed is identified as Watershed Resource Inventory Area (WRIA) 10 by the Washington State Department of Ecology.

The watershed supports eight species of anadromous fishes including six species of Pacific Salmon (*Oncorhynchus spp.*), coastal Cutthroat trout (*Oncorhynchus clarki*) and Bull trout *(Salvelinus confluentus)*. Prior to the construction of the Electron Diversion Dam in 1904, natural production occurred throughout the entire Puyallup River Basin. However, the dam, located at river mile R.M. 41.5, eliminated access to 21.5 miles of spawning habitat. In the fall of 2000, the Puyallup Tribe to reopened this habitat for fish use by installing a fish ladder in the Electron Dam.

The State of Washington began hatchery production within the watershed in 1914 at Voights Creek State Salmon Hatchery, located at R.M. 21.9 (Appendix A1). Currently, Voights Creek Hatchery rears fall coho, winter steelhead and fall chinook. In 1998, the Puyallup Tribe began planting hatchery-reared fall chinook and coho into the upper Puyallup watershed through the implementation of three acclimation ponds. These ponds, Cowskull, Rushingwater and Mowich, are located along the upper river. Cowskull pond drains directly to the Puyallup River at R.M. 45.5. The Rushingwater and Mowich ponds drain to the Mowich River, which enters the Puyallup at R.M. 42.3. In addition, surplus chinook and coho from Voights Creek Hatchery are released above Electron Dam and allowed to spawn naturally in an attempt to repopulate available habitat.

Puyallup River fall chinook were classified as a distinct stock by the 1992 State Salmon and Steelhead Stock Inventory (SASSI) on the basis of geographic distribution. In 1999, the National Marine Fisheries Service (NMFS) listed Puget Sound Chinook as a threatened species under the Endangered Species Act (ESA). Also in 1999, the Puyallup Tribe (PTF) and the Washington State Department of Fish and Wildlife (WDFW) created a joint fall chinook recovery plan with a goal of maintaining natural fall chinook production while evaluating system production potential and current stock status (WDFW and PTF, 2000). Estimating smolt production is a necessary step towards evaluating stock productivity and system production potential.

In 2000, the Puyallup Tribal Fisheries Department started the Puyallup River Smolt Production Assessment Project to estimate juvenile production of native salmonids, with an emphasis on natural fall chinook salmon production and survival of hatchery and acclimation pond chinook. Since 2000, an E. G. Solutions' 5-ft diameter rotary screw trap located on the lower Puyallup at RM 10.6, just upstream of the confluence with the White River, has been used to estimate juvenile production.

As more data become available, juvenile production estimates may provide baseline information allowing managers to re-evaluate escapement objectives in the watershed, create a production potential-based management strategy and accurately forecast future returns of hatchery and naturally produced adults. In addition, a basin spawner/recruit analysis will indicate stock productivity, helping to determine the overall health of the watershed and evaluate the contribution of enhancement projects.

GOALS AND OBJECTIVES

The goal of this project is to report production estimates, characterize juvenile migration timing, describe length distribution for all wild salmonid, out-migrants and fulfill the objectives of the Puyallup River fall chinook recovery plan.

To reach these goals, this study will produce population estimates of out-migrating smolts, estimate species specific migration timing, compare natural versus hatchery production and run timing, analyze mean fork length of wild smolts and detail species composition of the sample population. The objectives of this project are to:

1. Estimate juvenile production for all salmonids in the Puyallup River and determine freshwater survival for unmarked juvenile chinook.

2. Estimate in-river mortality of hatchery and acclimation pond chinook.

3. Investigate physical factors such as, light (day vs. night), flow and turbidity and their importance to trap efficiency.

In this report for the 2004 smolt out-migration season all stated objectives will be met for chinook salmon. Non-target species such as coho, pink, chum and steelhead will be addressed to a lesser extent.

MATERIAL & METHODS

Trapping Gear and Operations

The rotary screw-trap used in this study consists of a rotary cone suspended within a steel structure on top of twin, 30-foot pontoons. The opening of the rotary cone is 5 feet in diameter, allowing for a sampling depth of 2.5 feet. The cone and livebox assembly are attached to a steel frame and may be raised or lowered by hand winches located at the front and rear of the assembly (Appendix A2).

Two five-ton bow-mounted anchor winches with 3/8'' steel cables were used to secure and adjust the direction of the trap and keep it in the thalweg (Appendix A3). The cables were secured to trees on opposite banks. An additional rear cable was secured to a tree on the right bank along with an aluminum "stiff-arm" to further stabilize the trap. Four 55-gallon containers filled with water were secured on the deck at the rear of the trap to compensate for the generation of force at the front of the trap during operation.

The 5-ft diameter rotary screw trap was installed in the lower Puyallup River (R.M. 10.6) just above the confluence with the White River. Trap operation began on February 26th at 1330 and continued 24 hours a day, seven days a week until August 11th at 0830, with the exception of an 88-hour period between May 26th and May 30th when the trap was pulled due to a high flow event. The trap was checked for fish twice a day at dawn and dusk. In some instances, the trap was checked plus or minus two hours of dusk or dawn due to the availability of personnel. During hatchery releases and high flow events, personnel remained onsite through the night to clear the trap of debris and to keep the fish in the livebox from overcrowding.

Revolutions per minute (rpm), water temperature, secchi depth (cm), turbidity (NTU), weather conditions, and stream flow (cfs) were recorded for each completed trap check. A cross sectional area of the river at the smolt trap was taken to monitor channel morphology at the site (Appendix A4).

Sampling Procedures

Smolts were anesthetized with MS-222 (tricaine methanesulfonate) for handling purposes and subsequently placed in a recovery bin of river water before release back to the river. Juveniles were identified as natural or hatchery-origin. All hatchery fish in the Puyallup system are marked with an adipose fin clip or a coded wire tag. Therefore, unmarked fish are identified as natural and marked fish are identified as hatchery origin.

Hatchery-origin fish were identified in three ways: 1) by visual inspection for adipose fin (Ad) clips, 2) with a Northwest Marine Technology "wand" detector used for coded wire tag (CWT) detection, and 3) with a Destron Fearing Portable Transceiver system for Passive Integrated Transponder (PIT) tagged fish.

Fork length (mm) was measured and recorded for unmarked fish. When possible, 50 chum, 50 pinks, 50 age 1+ coho, 25 age 0+ coho, 25 age 0+ chinook, and 25 steelhead were measured each day. Scale samples were additionally taken on all wild steelhead smolts.

Species were separated by size/age class. Coho were identified as fry, age 0+ (<70mm) or smolts, age 1+ (>70mm). Chinook smolts were separated by age 0+ (<150mm) or age 1+ (>150mm). All chum and pinks were identified as age 0+. Trout fry age 0+ (<60mm) were not differentiated to species.

Measuring Flow and Turbidity

Stream flow measurements were obtained from the United States Geological Surveys (USGS) Alderton gauge (USGS 2004). Mean daily flow was recorded throughout the sample season and stream flow was noted during each capture efficiency release.

Turbidity was measured by taking secchi depth (cm) and water samples off the front of the trap during each trap check. Water samples were measured in nephlometric turbidity units (NTUs) using a Hach 2100A Turbidimeter. Mean daily secchi depth and mean daily NTUs were calculated by averaging one evening check reading with one morning check reading from the following day. In order to expand secchi readings during the high flow event on May 26th to May 29th, one secchi reading was taken on May 27th and applied to the missing days to complete flow and turbidity analyses.

Capture Efficiency

Release sites for capture efficiency tests varied for each species. Chinook were released 0.4 miles above the smolt trap, while coho, chum and pinks were released at the same site 0.2 miles above the trap. The time of release also varied for each species and is described below.

Chinook - Chinook reared at Clarks Creek Tribal Hatchery were used to complete capture efficiency tests throughout the chinook migration period. Fish were anesthetized with MS-222 and clipped with either an upper or lower caudal clip. Fish were then transferred to two large aerated containers and immediately moved upstream and released 0.4 miles from the smolt trap. The marked fish were released at either day or night times in order to examine differences in capture efficiency as a result of daylight. Night release groups were released after sunset and day groups were released with several hours of daylight left until dusk. No control groups were held for releases but all fish were vigorous at release.

Coho – Coho releases were completed using hatchery fish caught in the screw trap. Fish were anesthetized with MS-222 and clipped with either an upper or lower caudal clip. The fish were then transferred to an aerated container where they where held until being released 0.2 miles upstream from the smolt trap. Coho were captured in the morning and released later that evening and were not held longer than 16 hours. No control groups were held for releases but all fish were vigorous at release.

Chum –Wild chum captured in the screw trap and hatchery chum obtained from Diru Creek Tribal Hatchery were used to complete capture efficiency tests. All fish were marked with Bismarck Brown Y Biological Stain solution. Fish were placed in an aerated stain solution of 0.4 grams Bismark Brown per 5 gallons of water and held in the solution for 40-45 minutes. After marking, hatchery fish were placed back into juvenile raceways until release. Wild chum were marked and held in a large aerated container on the screw trap until release. Marked fish were released at day and evening times in order to examine the effect of daylight on trap efficiency. Evening release groups were released at dusk and day groups were released with several hours of daylight until dusk. All fish were captured, marked, and released within 24 hours to reduce stress. Control groups of 25 fish were held for each wild and hatchery release group to monitor for dye retention and mortality.

Pink – Wild pinks caught in the screw trap were used to complete capture efficiency tests throughout the pink migration period. Pinks were marked with the Bismarck Brown Y Biological Stain solution and held according to the same methodology as chum. All marked fish were held on the screw trap for less than 24 hours and released at either day or evening times in order to examine the effect of daylight on capture efficiency. Evening release groups were released at dusk and day groups were released with several hours of daylight until dusk. In order to monitor dye retention and mortality, control groups of 25 fish were held for each release group.

Catch Expansion

During the high flow event from May 26th to May 30th the trap was pulled in order to avoid damage from debris. The trap was not fishing for a total of 88 hours during this time. The trap was fished and continually monitored for a four-hour period during the rising flows from 1300 to 1700 on the 26th. Due to the high volume of fish in the trap, compounded by a high debris load, estimates were drawn by sampling every eighth net full, for numbers, species and the ratio of hatchery to wild fish.

Chinook-Voights Creek hatchery released 1,447,009 Ad clipped chinook and 199,665 Ad+CWT chinook for a total of 1,646,664 chinook on the morning of May 26th; therefore, we were unable to sample the majority of the Voights Creek chinook in the outmigration.

During the four-hour period prior to pulling the trap an estimated 13,157 Ad chinook and an estimated 1,794 Ad/CWT chinook were sampled. These estimates were converted to fish per hour and then expanded at that rate for an additional two hours on May 26th only, in an attempt to reflect the peak of hatchery migration. For the following three days the catch from the first two full day and night sample periods was applied as a rough estimate of hatchery chinook missed. Catch of unmarked chinook for May 27th - May 29th was estimated using the average catch over the first two 24-hour periods (May 30th and May 31st) following the traps reintroduction.

Coho-Total catch from May 25th was applied to May 26th - May 30th for all unmarked coho, hatchery coho and coho fry. This date was chosen as the most representative 24-hour catch period.

Other Species-We did not expand catch numbers for the other salmon species including: pink, chum, cutthroat and hatchery and wild steelhead to account for the fish we may have missed during the period the trap was not fishing. These species were not exhibiting peak migration during this time.

It should be noted that in light of these catch expansion methods, we assume that we are grossly underestimating potential catch for all sample groups for the period when the trap was not fishing.

Production Estimates

Due to the environmental complexities in estimating production of migrating juvenile salmon, production estimates for each species were calculated in a different way. Although production estimate methods were different, capture efficiency was calculated in a similar manner for each species using an estimate of capture efficiency (*e*) of the trap for a species and the total catch by the trap (either for the season or a defined period of time).

$$\hat{e} = r / m$$
$$\text{and}$$
$$\hat{N} = C / \hat{e}$$

where $\hat{e}$ = estimated capture efficiency, r = number of marked fish recaptured, m = number of marked fish released, $\hat{N}$ = total estimated number of unmarked migrants passing the trap, C = total number of unmarked fish caught in the screw trap.

Since our trap was checked twice in a 24-hour period (once in the morning and once in the evening) each morning check reflects the number of fish caught during the previous night and each evening check reflects the number of fish caught during the day. When calculating the total number of migrants passing the trap (*N*), the number of unmarked fish caught in the smolt trap (C) is the number of fish caught during each date's respective day or night period and is not the total number of fish counted on the date the trap was checked. In this report, one day will reflect the total number of fish caught in a combined day and night period. For some species the number of unmarked fish caught in the trap (C) is the sum over some specified amount of time, e.g., a week or season.

In order to characterize production and aide in production estimates, catch per unit effort (CPUE) was calculated using the total number of hours the trap was run divided into the number of fish caught during those hours.

Chinook – To estimate daily capture efficiency, mark-recapture tests were fitted to several non-linear and linear models using the SPSS statistical computing program (Norusis 1994). All capture efficiency tests, regardless of release time, were used when fitting the models to the data. To determine which model fit our data best the coefficient of multiple determination (r^2) and mean square error (MSE) was used to compare models. A thorough

discussion of the methods used to generate and estimate capture efficiency models is outlined in Conrad and MacKay (2000).

After a model was chosen, morning and evening secchi depth readings were averaged for each day and applied to the best fit model to estimate capture efficiency for a one day period. Total production estimates were then calculated for unmarked and marked juvenile chinook by dividing daily catch totals by daily capture efficiency estimates and summing daily totals.

In order to estimate capture efficiency using secchi depths for the period between May 26th and May 29th, a secchi depth reading was taken on the 27th. A secchi depth of 15 cm was used to produce a production estimate from expanded numbers of hatchery chinook catches for each day that the trap was not fishing. An average of the production estimates measured for May 30th and 31st was used to produce a production estimate for unmarked chinook over the period when the trap was not fishing.

To examine the effects of night, day and turbidity on capture efficiency, release groups of night versus day, and before versus after the glacial melt period (June 23rd), were tested for significance using Fishers exact test on SPSS software (Norusis, 1994).

Coho – No production estimates were completed for coho due to the lack of capture efficiency tests completed throughout the migration period.

Chum – A total production estimate for chum was generated by using the combined season efficiency from all wild chum releases completed throughout the season and applying it to daily catch totals. All daily catch totals were summed for a total production estimate. Although both wild and hatchery chum were used during mark recapture tests, only wild chum efficiency results were used to estimate overall capture efficiency. Wild chum should reflect the complexities of chum migration, i.e., flow, turbidity, lunar cycles and variation in size of smolts, better than their hatchery counterparts.

Wild and hatchery chum release groups were tested for significance, between and within groups, using Fisher's exact test (Norusis, 1994). Wild and hatchery chum releases were compared to examine the difference in hatchery and wild fish behavior/movement, and its relevance to capture efficiency.

Pink – A total production estimate for pink salmon was completed by using a combined weekly efficiency for each statistical week applied to each 24-hour catch period within that statistical week. Production estimates for each week were combined for a total production estimate. A season capture efficiency average was not used for pink salmon because a sufficient number of tests were performed every week and a weekly average is a better reflection of trap efficiency than a season average.

RESULTS AND DISCUSSION

Flow and Turbidity

Flow and turbidity were measured throughout the trapping season from Feb. 26th to Aug. 11th. Turbidity and flow remained stable until the high flow event on May 25th when turbidity and flows increased over a five-day period (Figure 1). Starting on June 23rd, turbidity and flow regimes reached a steady period of dominance by glacial melt runoff. This period will be called the glacial melt period (June 23rd – August 11th).
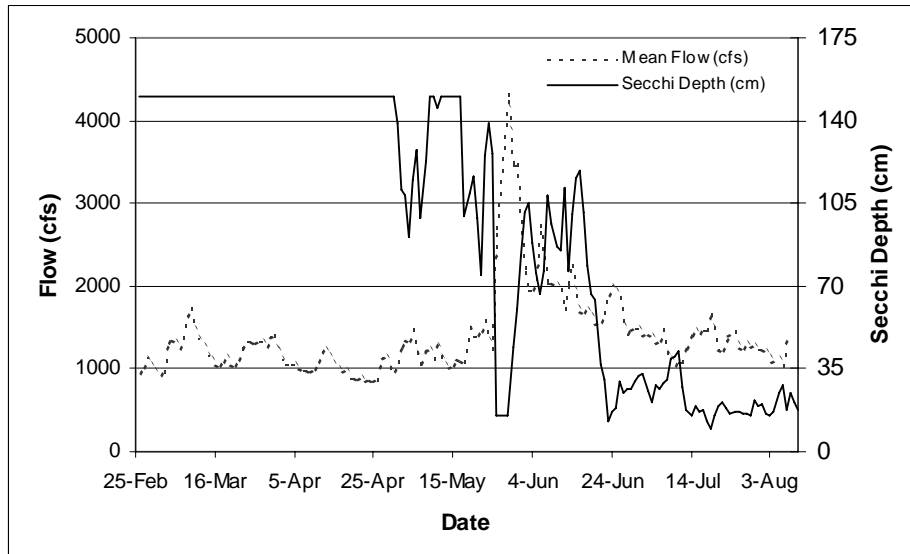
Figure 1. Correlation of mean daily flow and secchi depth for Puyallup River , 2004.

Throughout the trapping season flow did not significantly explain the variation of turbidity (Figure 2). Flow may not explain turbidity due to the presence of overlapping flow types on the Puyallup River (ie snow melt, overland flow and glacial runoff). If different flow types contribute varying concentrations of suspended loads then the lack of correlation seems reasonable.

Although no relationship exists between mean daily flow and secchi depth, timing of large fluctuations in turbidity and flow reflect one another (Figure 1). Since flow does not explain secchi depth, but large-scale changes in turbidity and flow concur, then other environmental variables must contribute to fluctuations in turbidity (i.e. glacial melt).
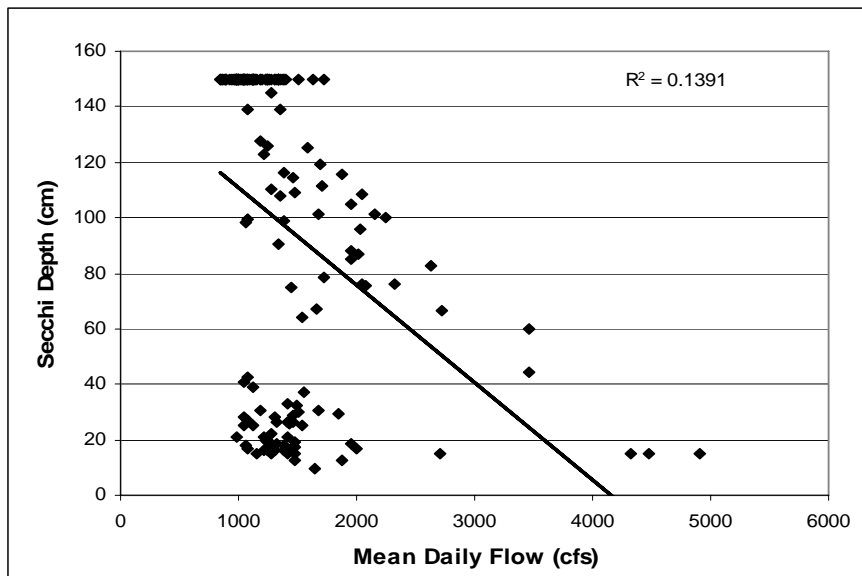
Figure 2. Secchi depth and mean daily flow for Puyallup River screw trap 2004.

CHINOOK

Catch and Migration Timing

Unmarked Chinook
We captured a total of 795 unmarked chinook smolts during trap operation in 2004. The first chinook was caught on March 1st and the last on August 6th. Even though catch varied considerably from day to day, overall catch occurred in two peaks (Figure 3a). Over 45% of the chinook were captured during the first catch peak, between May 24th and June 13th, and 24% of the catch occurred in a second peak between June 21st to July 4th. These peaks in catch correlate with two major, contributing environmental conditions. The first peak occurred during a high flow event on the Puyallup River, in which mean daily flows crested at 4900cfs on May 28th. The second peak coincided with the onset of the glacial melt period on June 23rd.

Stock abundance estimates based entirely upon catch do not take into account the influence of a dynamic river system on the capture efficiency of the screw trap. This year we found a high correlation ($r^2 = 0.984$) between secchi depth and capture efficiency of the screw trap on the Puyallup River (Figure 9). Conrad and MacKay (2000) also found a positive correlation ($r^2 = 0.841$) between secchi depth and chinook capture efficiency on the Nooksack River. For this reason, we additionally looked at migration timing as a function of capture efficiency based upon daily estimated production. When examined in this way, we did not see a migratory peak occurring around the 23rd of June (Figure 3b). Therefore, this peak in catch indicates an increase in capture efficiency of the screw trap and not a peak in migration. Daily production estimates indicates more chinook migrating earlier in the season when the river is clear.

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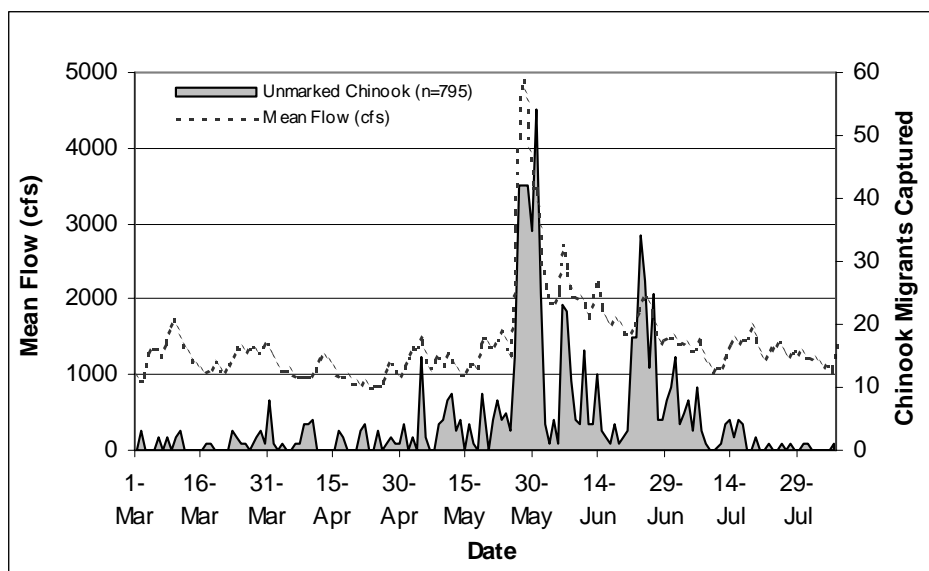
Figure 3a. Daily catch of unmarked chinook migrants captured in the screw trap with mean daily flows.
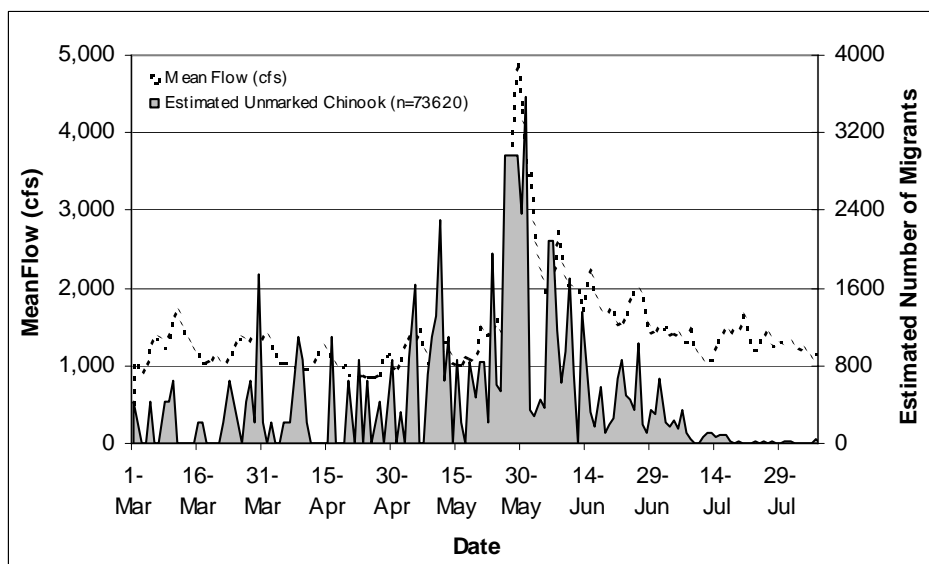
Figure 3b. Estimated daily migration of unmarked chinook smolts from screw trap catches with mean daily flows.

Based upon our production estimates, 25% of unmarked chinook migrated between March 1st and May 4th, 50% migrated by May 26th, and 75% had left by June 5th (Figure 4). The last 25% of chinook migrated between June 5th and August 6th.

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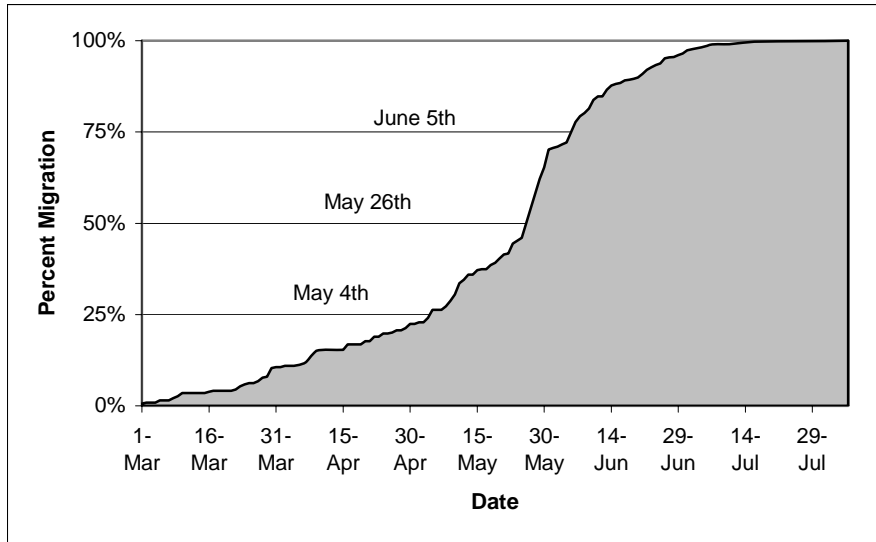
Figure 4. Percent estimated daily migration of unmarked age 0+ chinook.

The importance of glacial melting and its relevance to migration timing and capture efficiency of the trap is shown in Tables 1 and 2. The majority of unmarked chinook, 74% of total catch and 92% of the estimated production, migrated past the trap before the beginning of the glacial melt period. Further, 72% of total production and 58% of total catch occurred before the glacial melt period during night hours. For the entire season, day:night catch ratios were 26% for catch and 28% for estimated production. Seiler et al (2004) found a similar relationship between day and night catch ratios at 28%. However, Sieler et al (2004) also reported a weak correlation between day:night catch ratios and conditions of high turbidity.

Table 1. Total unmarked chinook production before and after glacial melt period

Date	Day	Night	Total
2/29 thru 6/22	15095 (20.50%)	52643 (71.51%)	67738 (92.01%)
6/23 thru 8/11	988 (1.34%)	4894 (6.65%)	5882 (7.99%)
Total	16083 (21.8%)	57537 (78.2%)	73620 (100%)

Table 2. Total unmarked chinook catch before and after glacial melt period

Date	Day	Night	Total
2/29 thru 6/22	134 (16.86%)	455 (57.23%)	589 (74.09%)
6/23 thru 8/11	32 (4.03%)	174 (21.89%)	206 (25.91%)
Total	166 (20.9%)	629 (79.1%)	795 (100%)

Marked Chinook
We captured a total of 27,708 marked chinook smolts in the screw trap this year.
Marked chinook from Voights Creek Hatchery were released 11 miles upstream from the
screw trap, during the high flow event on May 26th. Based upon expanded catches for
May 26th, we estimated a one-day catch of 22,427 marked chinook and a production
estimate of 411,108. The flow event from May 26th to May 31st, pushed a large
percentage of fish past the screw trap, 86% of total catch and 49% of total estimated
production. Migration based upon catch and estimated production was unimodal with
migration lasting from April 8th to August 6th.
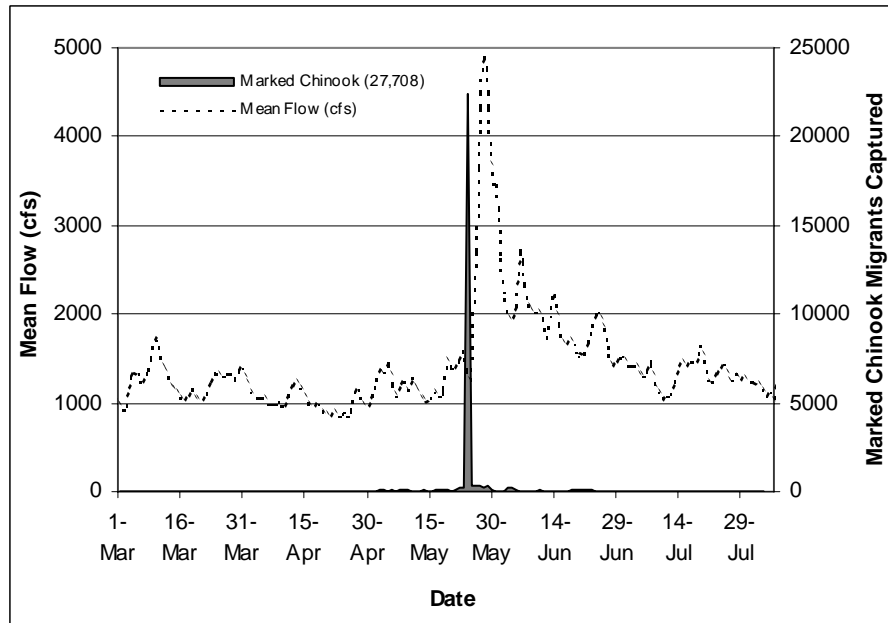
Figure 5a. Daily catch of marked chinook migrants captured in the screw trap with mean daily
flows.
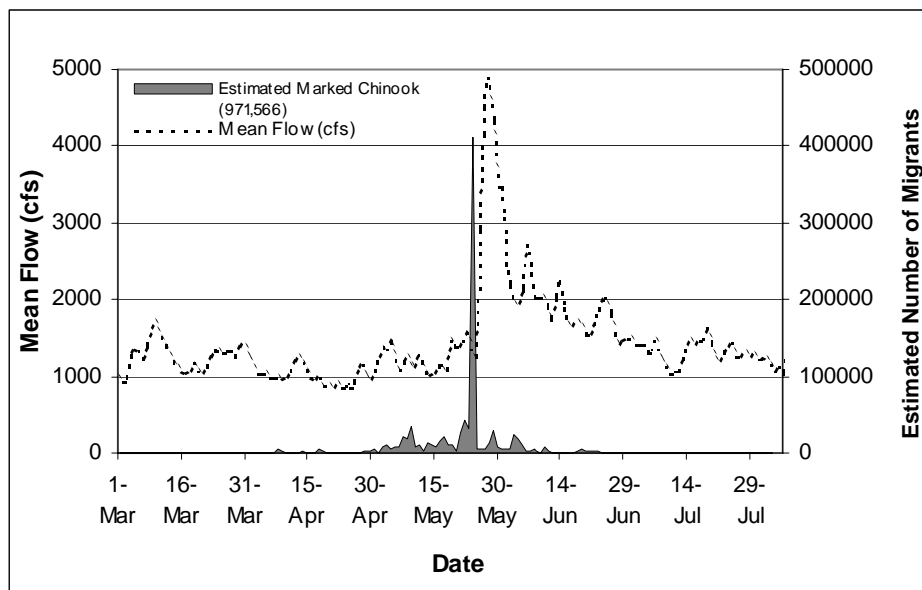
Figure 5b. Estimated daily migration of marked chinook smolts with mean daily flow.

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Size

From March 1st through April 25th (statistical weeks 10-17) the mean fork length of unmarked age 0+ chinook consistently measured between 41mm and 55mm (Figure 6). However in the following week of April 26th through May 2nd, week 18, there was an increase in mean fork length from 48mm to 80mm, albeit, we sampled chinook as small as 38mm. While there was a positive trend towards increased mean fork length throughout the season, the size range of chinook sampled remained large, sometimes ranging from 49mm to 120mm in one week. Over the entire season, mean weekly fork length of age 0+ chinook sampled in the screw trap increased from 41mm to 102mm (Appendix D1).
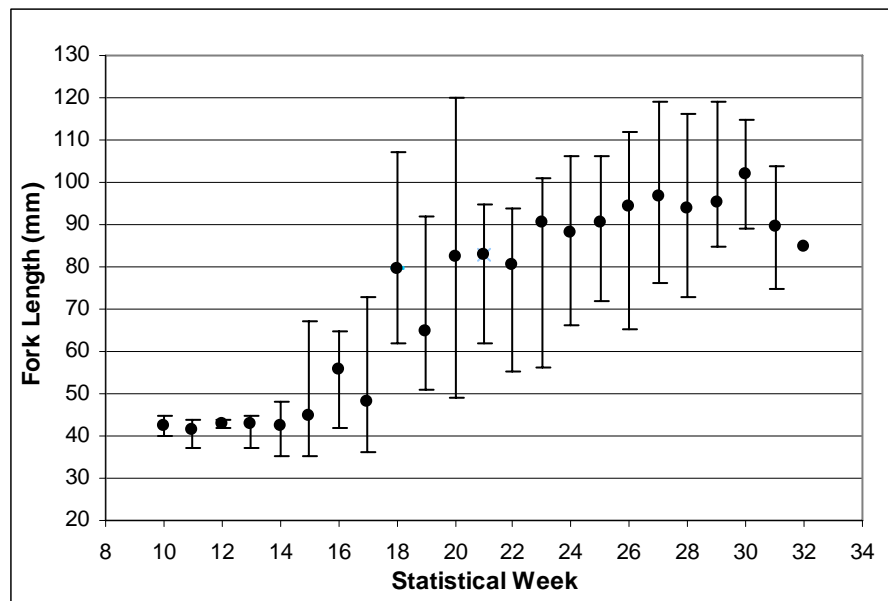
Figure 6. Mean weekly fork length and size range of unmarked age 0+ chinook captured in the screw trap.

Capture Efficiency

Day and Night

Sixteen day and night capture efficiency tests were completed throughout the chinook migration period (Appendix B1). Release group size ranged from 595 to 800 with a total of 9,133 chinook released. Capture efficiencies ranged from 0.326% to 5.921%, with tests results remaining relatively consistent until June 23rd. After June 23rd a large increase in estimated capture efficiency occurred (Figure 7). This is the approximate date of the glacial melt period.
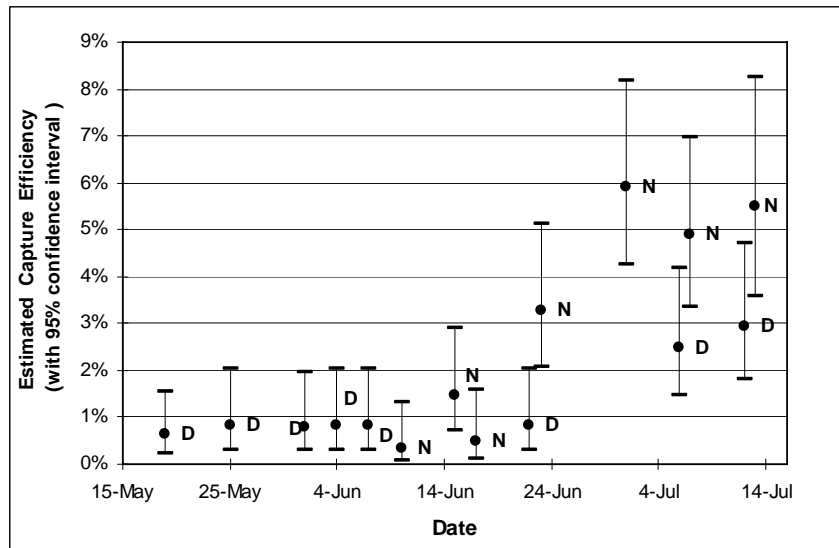
Figure 7. Estimated chinook capture efficiency with 95% confidence intervals for day and night mark-recapture tests (D and N respectively denote day and night releases).

Since there was a significant increase in capture efficiency tests after June 22nd, all capture efficiency tests were tested for difference between four test groups, in five separate cases. The four test groups were, 1. Day releases ($\leq$ June 22nd), 2. Night releases ($\leq$ June 22nd), 3. Day releases ($\geq$ June 23rd) and 4. Night releases ($\geq$ June 23rd).

Case 1. There was a significant difference in trap efficiency among all four test groups (*P*<0.001) (Table 3a.)

Table 3a. Crosstabulation of day and night mark-recapture tests before June 22nd and after June 23rd.

		Not Recaptured	Recaptured	Released
DAY	**Count**	**3822**	**30**	**3852**
$\leq$ June 22nd	% within group	99.2%	0.778816%	100.0%
NIGHT	**Count**	**1804**	**14**	**1818**
$\leq$ June 22nd	% within group	99.2%	0.770077%	100.0%
DAY	**Count**	**1178**	**33**	**1211**
$\geq$ June 23rd	% within group	97.3%	2.725021%	100.0%
NIGHT	**Count**	**2143**	**109**	**2252**
$\geq$ June 23rd	% within group	95.2%	4.840142%	100.0%
TOTAL	**Count**	**8947**	**186**	**9133**
	% within group	98.0%	2.036571%	100.0%

Case 2. For the entire test season, there was a significant difference between day and night capture efficiencies ($P<0.001$) (Table 3b.).

Table 3b. Crosstabulation of day and night mark-recapture tests for the entire season.

	Not Recaptured	Recaptured	Released
DAY Count	**5000**	**63**	**5063**
% within group	98.8%	1.244322%	100.0%
NIGHT Count	**3947**	**123**	**4070**
% within group	97.0%	3.022113%	100.0%
TOTAL Count	**8947**	**186**	**9133**
% within group	98.0%	2.036571%	100.0%

Case 3. There was a significant difference between capture efficiency periods before June 22nd and after June 23rd ($P<0.001$) (Table 3c).

Table 3c. Crosstabulation of mark-recapture tests before June 22nd and after June 23rd.

	Not Recaptured	Recaptured	Released
≤ June 22nd Count	**5626**	**44**	**5670**
% within group	99.2	0.776014	100.0%
≥ June 23rd Count	**3321**	**142**	**3463**
% within group	95.9%	4.100491%	100.0%
TOTAL Count	**8947**	**186**	**9133**
% within group	98.0%	2.036571%	100.0%

Case 4. Day and night capture efficiencies for the period after June 23rd showed a significant difference ($P=0.003$) (Table 3d.).

Table 3d. Crosstabulation of day and night mark-recapture tests after June 23rd.

	Not Recaptured	Recaptured	Released
DAY Count	**1178**	**33**	**1211**
% within group	97.3%	2.725021%	100.0%
NIGHT Count	**2143**	**109**	**2252**
% within group	95.2%	4.840142%	100.0%
TOTAL Count	**3321**	**142**	**3463**
% within group	95.9%	4.100491%	100.0%

Case 5. Day and night capture efficiencies for the period before June 22nd showed no significant difference ($P=1.00$) (Table 3e.)

Table 3e. Crosstabulation of day and night mark-recapture tests before June 22nd.

	Not Recaptured	Recaptured	Released
DAY Count	**3822**	**30**	**3852**
% within group	99.2%	0.778816%	100.0%
NIGHT Count	**1804**	**14**	**1818**
% within group	99.2%	0.770077%	100.0%
TOTAL Count	**5626**	**44**	**5670**
% within group	99.2%	0.776014%	100.0%

Statistical testing of estimated capture efficiency indicates that the relationship between day and night tests are different and the trap is more efficient at capturing chinook during the night and after June 23rd (Table 3b and 3c). There is a difference in day and night capture efficiency after the glacial melt period, but no difference before (Table 3d and 3e). This relationship is counter-intuitive to what we expected to see. In a more turbid environment we would expect fish to be caught at a similar efficiency regardless of light conditions. There may be two reasons for our findings:

1. There were not enough trap efficiency tests completed for each statistical group to show a conclusive relationship for day and night tests before the glacial melt period. Only two releases were used for day/night analysis after June 23rd.
2. The increase in size of hatchery fish used for releases over time influenced the day and night efficiency tests. This possibility is hard to examine since turbidity undoubtedly influenced the capture efficiency of the trap later in the season when larger fish were used (Figure 8).
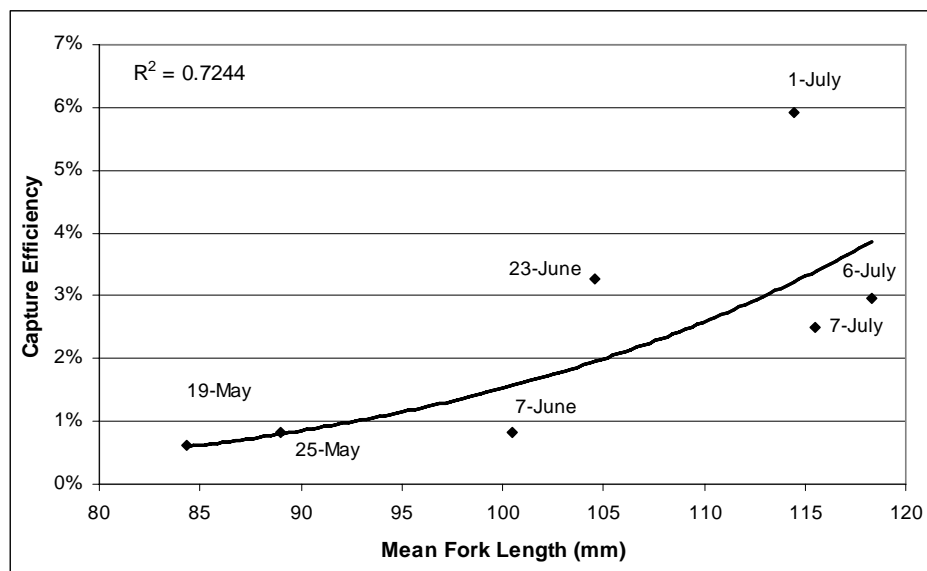
Figure 8. Exponential regression of capture efficiency and mean fork length of hatchery chinook used for mark-recapture tests.

Hatchery Chinook Length
Seven of the sixteen capture efficiency tests have length data. Conrad and MacKay (2000) found a strong negative correlation between mean length of chinook used for mark-recapture tests and estimated capture efficiency. Our data indicates a positive correlation ($r^2 = 0.7244$) between mean length and capture efficiency, suggesting that the trap is more efficient at capturing larger chinook (Figure 8). Due to the small sample size it is difficult to determine whether this relationship is significant or merely an artifact of increased turbidity later in the season.

Capture Efficiency Models

Of the models evaluated, the power curve correlating secchi depth (Figure 9) and the exponential curve correlating flow (Figure 10) fit our data best (Table 4). Although both correlations are significant ($P<0.001$) the power curve with secchi depth was the best fitting model and was chosen as our estimator of production. The following equation was used to estimate daily production: Capture Efficiency = Secchi Depth ^ -1.074053.
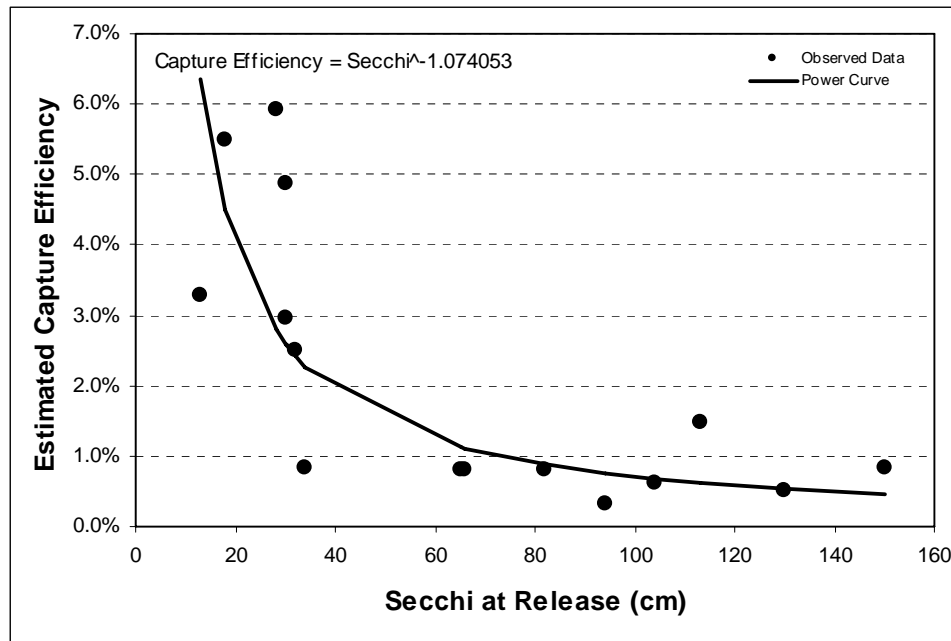
Figure 9. Power curve correlating capture efficiency and secchi depth readings measured at the time of chinook release ($r^2 =0.984$; $P<0.001$).
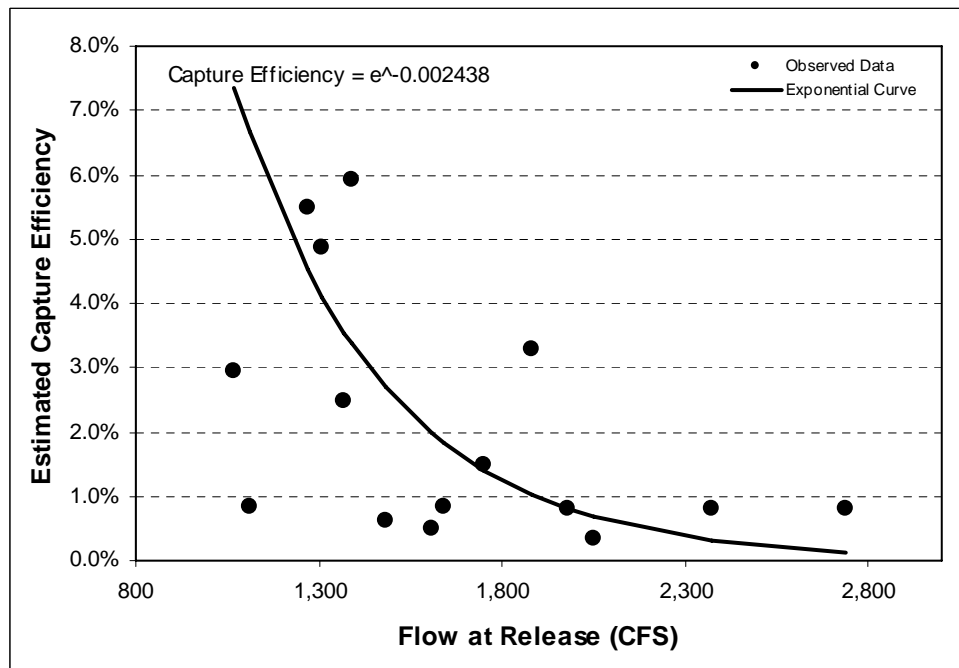
Figure 10. Exponential curve correlating capture efficiency and flow measured at the time of chinook release ($r^2= 0.941$; $P<0.001$).

Table 4. Capture efficiency model testing, Puyallup River, 2004

Parameter:	Secchi Depth (cm)		River Flow (cubic ft/sec)	
Model[*]	Adj r^2 [**]	Model P	Adj. r^2	Model P
Linear (C)	45.1%	0.0036	16.9%	0.0716
Logarithmic (C)	54.9%	0.0010	NA	NA
Inverse (NC)	75.8%	0.0000	62.2%	0.0002
Power (NC)	98.3%	0.0000	92.0%	0.0000
Exponential (NC)	66.1%	0.0018	93.7%	0.0000

[*](C) indicates constant was included in the model; (NC) indicates that the constant was not significant ($P > 0.05$) and the constant was not included in the model.
[**] Adj. r^2 = adjusted r^2.

Estimated Production

An estimated total of 73,620 unmarked chinook passed the screw trap between March 1st and August 6th and an estimated total of 971,566 marked hatchery chinook passed the trap between April 8th and Aug 6th (Appendix C1, C2 and C3). After all 0 catch days were removed from daily production estimates, mean daily flow partly explained production (Figure 11). Variability of river conditions, such as turbidity, may have affected the correlation between flow and production. Although the relationship is weak, the importance of flow to daily production should not be underestimated, future daily production estimates may yield different results.
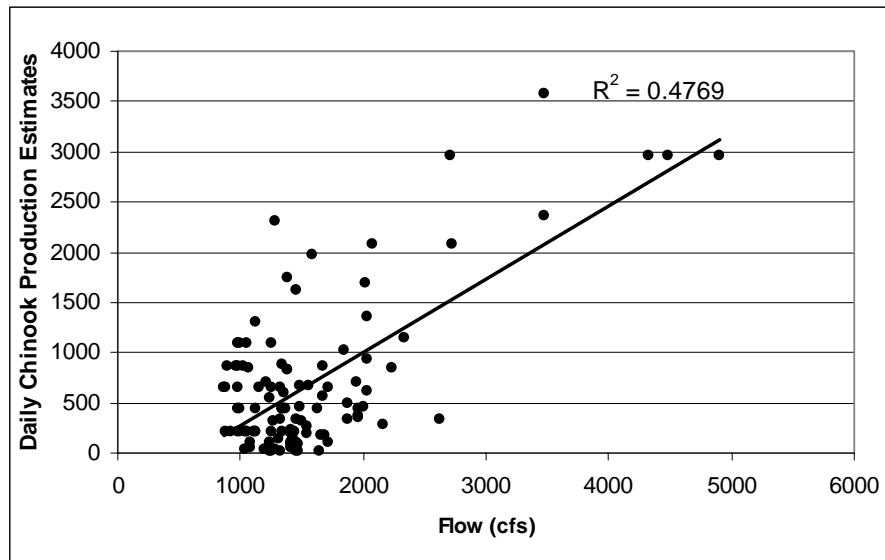
Figure 11. Regression of estimated daily production of unmarked chinook and flow.

Freshwater Survival

In-River Mortality of Hatchery Releases
A total of 1,749, 864 marked fall chinook were released into the Puyallup River from Voights Creek Hatchery (RM 21.9) and Cowskull acclimation pond (RM 45.5). All hatchery-origin chinook were marked with an Ad clip or Ad/CWT, which enabled us to estimate in-river mortality between hatchery release sites and the screw trap. Relating overall production estimates of hatchery chinook to the known number of hatchery fish released into the system gives us in-river mortality. Production estimates and in-river mortality are provided for each release group (Table 5). Total in-river mortality for all hatchery chinook combined was 44.48%. Seiler et al (2004) reported a similar in-river mortally of 40% for hatchery age 0+ chinook on the Skagit River.

We cannot differentiate Cowskull acclimation pond fish from Voights Creek fish, however, Cowskull fish are not part of the Ad/CWT group. The Ad/CWT group had less in-river mortality than the Ad clip group, 15.02% to 48.27% respectively. Further investigation is needed to determine why a large difference exists between mark groups.

Table 5. In-river mortality of marked chinook based upon production estimates from the Puyallup River screw trap 2004

Mark Type	Date		Number Released	Number Captured	Capture Percentage for Each Release Group	Estimated Production for Each Release Group	In-River Mortality for Each Release Group
	Start	End					
AD/CWT (Voights)[*]	26-May	26-May	199,655	3,620	1.81%	169,675	15.02%
AD (Voights)[*]	26-May	26-May	1,447,009	24,088	1.55%	801,891	48.27%
AD (Cowskull)	2-Jun	7-Jun	103,200				

[*] = Data gathered from Pacific States Marine Fish Commission

Freshwater Survival of Natural Smolts
Relating our total unmarked chinook outmigration estimate to our potential egg deposition gives us a freshwater survival estimate to the screw trap (Table 6). This estimate does not include mortality that may occur after fish pass the screw trap.

The number of females used to calculate the smolt-to-female ratio and egg production is based on the total number of fish, 1090, that spawned in the Puyallup River using an area under the curve estimate (AUC) (Scharpf, Pers. Comm.). The number of females, 464, was calculated from the male-to-female ratio from South Prairie Creek (Long, pers. comm.). A fecundity of 4,800 eggs/female, obtained from Voights Creek hatchery fall chinook, was used to estimate total egg production (Davis, Pers. Comm.).

Table 6. Freshwater survival of unmarked chinook smolts Puyallup River, 2004.

Run Year	Total Outmigration Estimate	Total Number of Females	Potential Egg Deposition	Smolt/Female	Maximun and Minimum Flows Aug.-Feb.*		Percent Freshwater Survival (#smolts / #eggs)
2003-2004	73620	464	2,227,200	159	1972	14	3.31%

* = Data gather from USGS Water Resource Divison

The freshwater survival estimate of 3.31% is lower than most other estimates in the Puget Sound area. Studies completed by the WDFW show freshwater survival rates from 5.3% to 7.3% on the Green River (Seiler et al 2004), to as high as 10.8% on the Skagit River (Seiler et al. 2004). However, lower estimates of 2.1% and 2.4% were found on Bear Creek, a tributary to Lake Washington (Seilar, et al, 2003). Freshwater survival estimates should be continued for the Puyallup River in order to understand the significance of the 2004 estimate.

COHO

Catch and Migration Timing

Unmarked Coho
The first unmarked coho was caught on March 7th and the last on July 23rd. Coho migration as reflected by catch, followed a fairly regular progression until the peak of the catch on May 11th , when we captured 39 fish in the trap. Ninety-three percent of the unmarked age 1+ coho were caught between April 19th and June 13th (Figure 12). The remainder of the catch occurred more sporadically through the season.
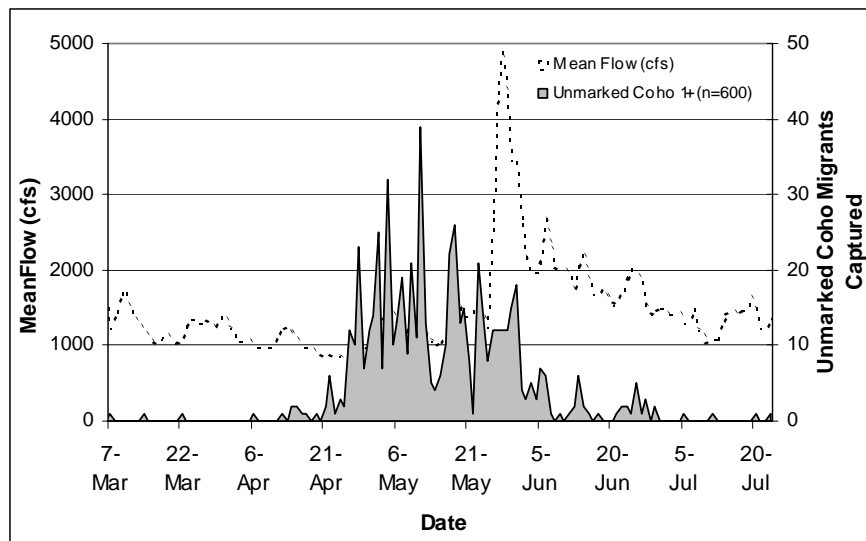
Figure 12. Daily catch of unmarked age 1+ coho migrants captured in the screw trap with mean daily flows.

Puyallup River Juvenile Salmonid Production Assessment Project 2004

Since we were not able to generate production estimates for coho, percent migration is illustrated with catch numbers. Twenty-five percent of catch occurred by May 3rd, 50% by May 12th and 75% by May 25th (Figure 13). The last 25% were caught between May 25th and July 23rd.
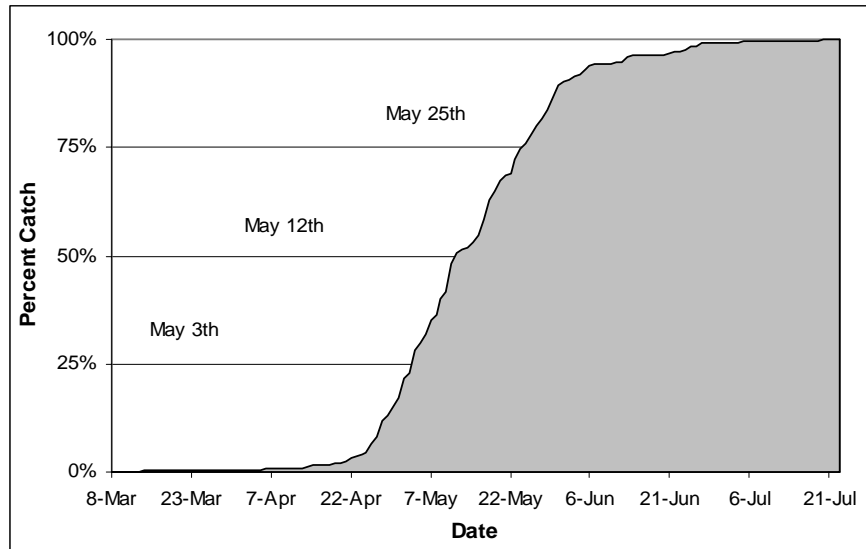
Figure 13. Percent catch of unmarked age 1+ coho in the screw trap.

Marked Coho

Voights Creek Hatchery began a volitional coho release on April 15th. Smolts were forced out by April 30. Forty-six percent of the marked age 1+ coho were caught between April 12th and April 18th (Figure 14). This suggests two things, (1) coho were getting out of the hatchery before the release date and (2) Voights Creek coho migrated through the system quickly and did not hold in the river. Hatchery release from Cowskull and Rushingwater acclimation ponds occurred from April 26th to April 30th. A smaller increase in catch occurred subsequent to this release from April 26th to May 9th, in which we captured 30% of the total marked coho catch
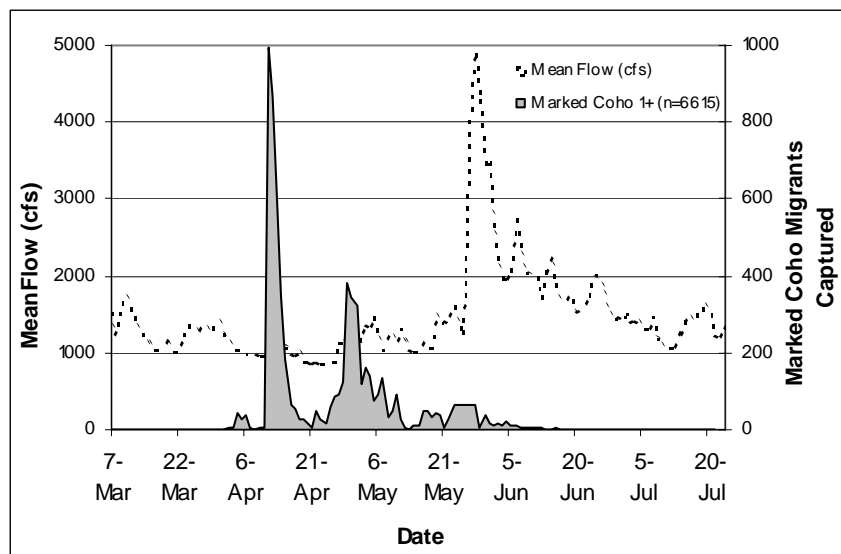
Figure 14. Daily catch of marked age 1+ coho captured in the screw trap with mean daily flows.

Puyallup River Juvenile Salmonid Production Assessment Project 2004

Size

Mean weekly fork length data collected over the smolt trap season presents little evidence of growth during the coho out-migration period (March to July). Fork length of the unmarked age 1+ coho sampled was wide ranging and showed no positive trend towards growth between weekly samples (Figure 15). Sizes of age 1+ coho sometimes ranged from 70mm to 157mm in one week (Appendix D2).
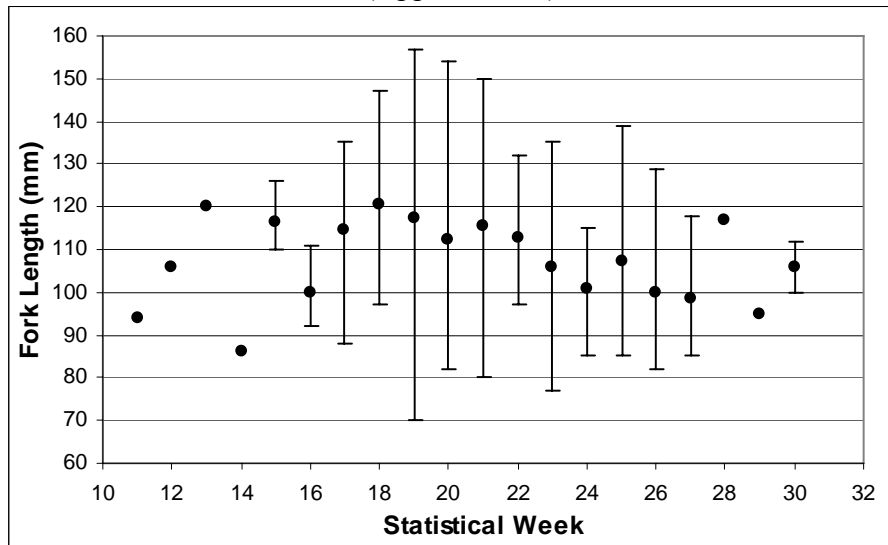
Figure 15. Mean weekly fork length and size range of unmarked age 1+ coho captured in the screw trap.

Capture Efficiency

Two coho releases were completed during the smolt trap season (Appendix B2). Due to the lack of holding space on the trap and low numbers of coho caught at any one time, no more releases were completed. Increasing the amount of space available for holding marked fish on the smolt trap, and/or taking fish directly from Voights Creek Hatchery, would ameliorate this problem.

Table 7 shows the difference between average capture efficiency tests completed 0.2 miles above the screw trap, and the overall catch percentage of hatchery coho released 11 miles above the screw trap from Voights Creek Hatchery.

Table 7. Hatchery release capture percentage and smolt trap average capture efficiency for marked coho Puyallup River Smolt Trap 2004

| Mark Type | Date | | Number Released | Number Captured | Capture Percentage for Each Release Group | Overall Hatchery Capture Percentage | Average Capture Efficiency from Smolt Trap Releases |
	Start	End					
CWT (Voights)*	15April	30-April	45,881	340	0.74%		
AD (Voights)*	15-April	30-April	756,060	5587	0.66%		
AD (Cowskull/Rushing water)	26-Apr	30-Apr	94,882			0.65%	1.67%
AD + CWT (Cowskull/Rushing water)	26-Apr	30-Apr	82,118	688	0.54%		
AD + CWT (Voights)*	15-May	30-May	46,059				

* = Data gathered from Pacific States Marine Fisheries Commission

Capture percentage of marked coho was highest among the release group belonging only to Voights Creek, followed by the Ad marked group with a majority of fish from Voights Creek and finally the Ad + CWT marked group with fish from Cowskull and Rushingwater acclimation ponds. This may indicate a lower survival rate of fish released from acclimation ponds. Mortality associated with migration through the Electron diversion dam and the rigors of a longer migration distance may be responsible for the lower survival of acclimation pond coho to the smolt trap. In addition, capture percentage for coho is less than hatchery chinook. Hatchery coho are larger and more mobile than chinook, and therefore more likely to exhibit trap avoidance.

Production Estimates
No production estimates were completed for coho due to the lack of capture efficiency tests completed throughout the migration period (Appendix C6).

CHUM

Catch and Migration Timing

A total of 2033 juvenile chum migrants were captured in the screw trap in 2004. The first chum migrant was caught on March 2nd and the last was caught on June 2nd (Figure 16). Catch varied considerably from day-to-day and progressed randomly throughout the season with no distinct peak in migration.
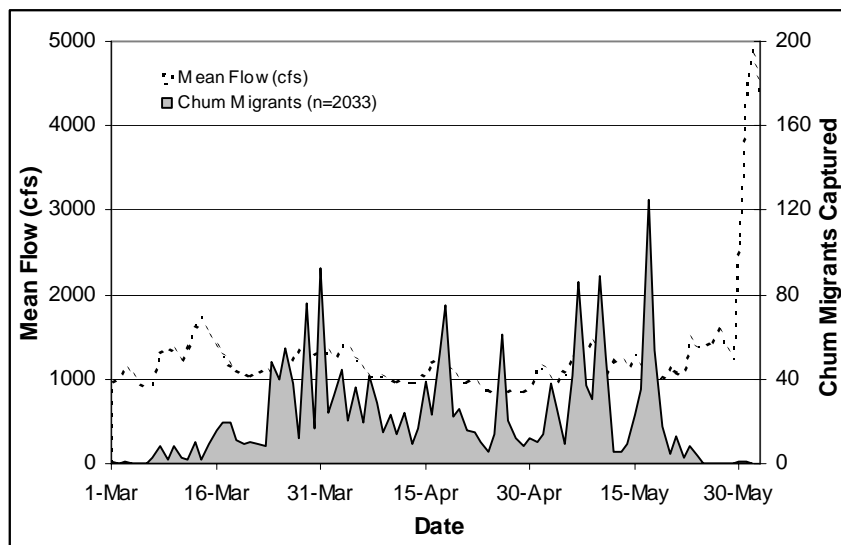
Figure 16. Daily catch of chum migrants captured in the screw trap and mean daily flows.

Chum migration occurred steadily over a three-month period. Twenty-five percent of chum migration occurred by April 2nd, 50% by April 19th and 75% by May 9th (Figure 17). The last 25% were caught between May 25th and June 2nd.
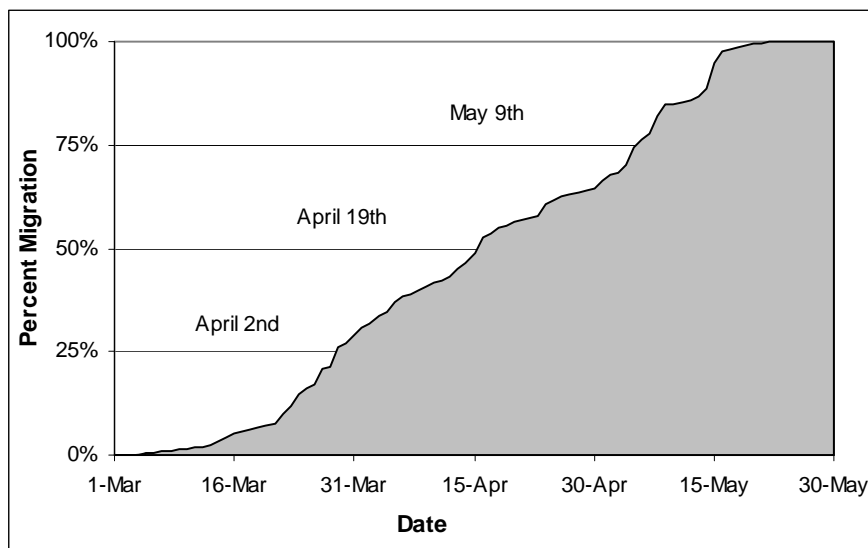
Figure 17. Percent estimated migration of chum.

Size

We found little difference in mean fork length of chum between sample weeks (Figure 18). However, the size range of chum sampled became progressively larger throughout the season. The maximum length of the chum sampled increased steadily throughout the

migration season from 41mm to 72mm between the first and last weeks sampled. The minimum length did not increase throughout the sample season (Appendix D3).
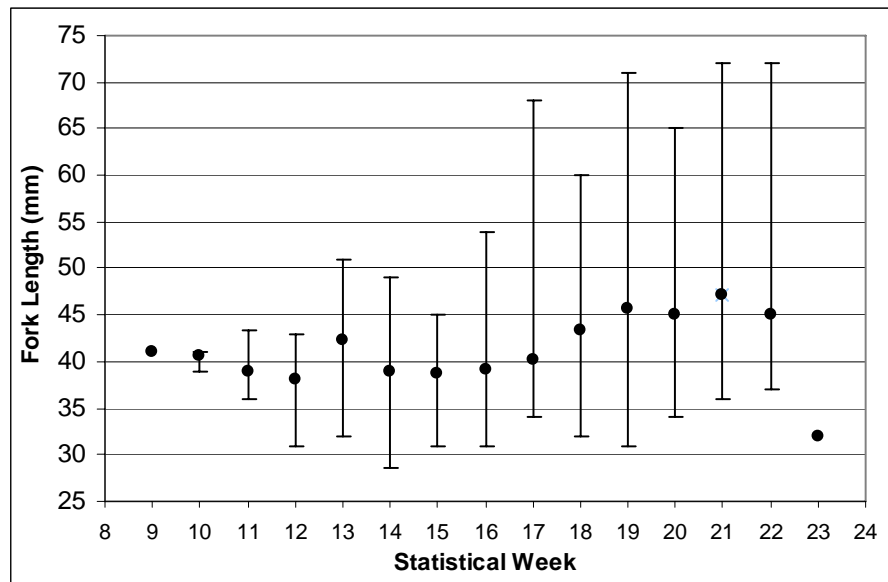
Figure 18. Mean weekly fork length and size range of chum captured in the screw trap

Capture Efficiency

Seven wild and seven hatchery chum releases were completed throughout the chum migration period (Appendix B3). A total of 3603 hatchery chum and a total of 1638 wild chum were released during mark recapture tests. Combined capture efficiency from the hatchery releases was 3.75% and 2.14% for wild releases. Fischers exact test of significance was conducted and indicated a significant difference in wild versus hatchery chum releases ($P = 0.002$). Seiler et al (2004) found similar results in which capture efficiency was greater for hatchery chinook than wild chinook. Since wild fish are a better subject than hatchery fish for releases, due to inherent behavior/movement, we used wild capture efficiencies to generate production estimates. There was not a significant difference among wild mark-recapture tests ($P = 0.067$).

Three daytime mark recapture tests and four night mark recapture tests were completed using hatchery chum (Figure 19). There was not a significant difference between day and night hatchery efficiency tests ($P= 1.0$). Therefore, no distinction was made between tests. However, in the future, day versus night tests should be completed using wild chum.
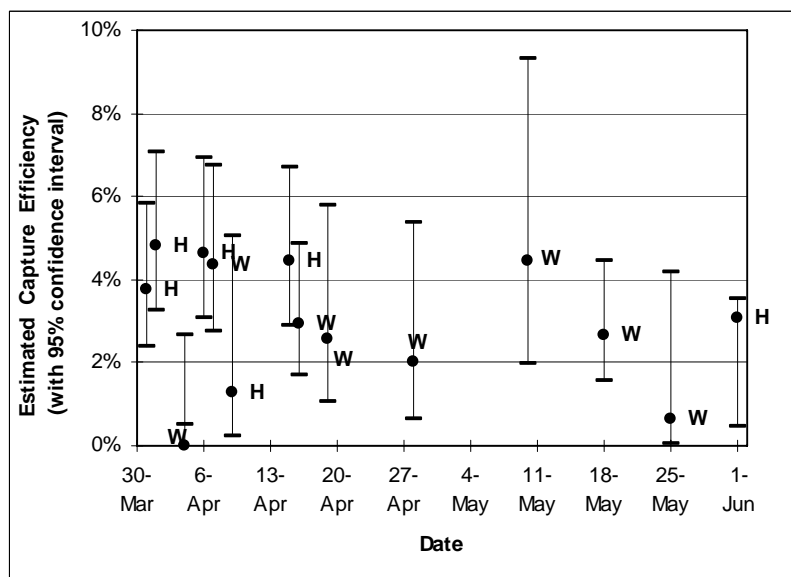
Figure 19 . Estimated chum capture efficiency with 95% confidence intervals for day and night mark-recapture tests. (H denotes hatchery chum and W denotes wild chum).

Flow did not explain the variation in estimated capture efficiency between all chum mark recapture tests, r^2=0.0326 (Figure 20). This relationship is hard to quantify since most mark-recapture tests were completed during similar flows. Flow remained relatively constant throughout the measured chum migration period.
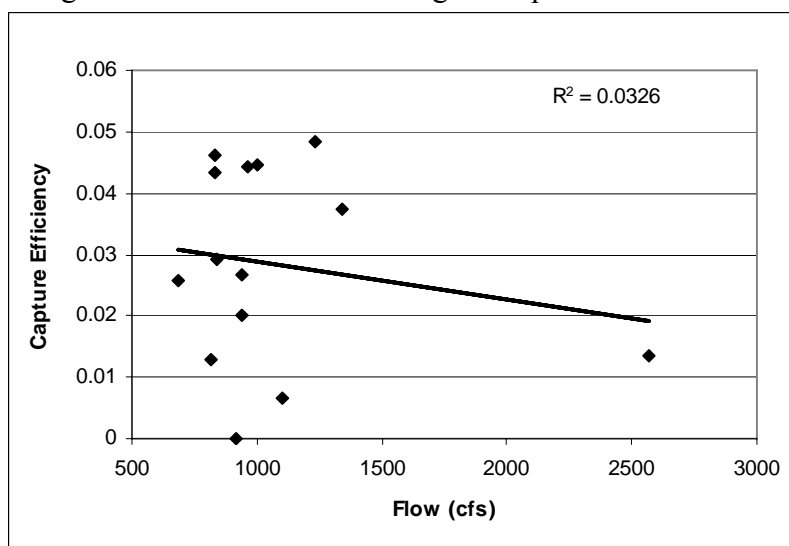
Figure 20 . Linear regression of capture efficiency and flow for chum fry.

Production Estimate

Since there was not a significant difference between wild capture efficiency tests a combined capture efficiency of 2.14% was used to produce a total chum production estimate. We estimated that 95,133 chum migrants passed the trap in 2004 (Appendix C4).

PINK

Catch and Migration Timing

We caught a total of 54,192 pink migrants in the smolt trap in 2004. We captured 60 pinks on the first day of trap operation on February 26th; therefore, it is possible that we may have missed a small portion of the migration season. We continued to catch pink migrants in the trap until June 1st (Figure 21). Even though catch varied from day to day pink migration followed a regular, unimodal curve, with the peak of the season occurring on March 28th, when 3,478 fish were caught in one 24-hour period (Appendix C5).
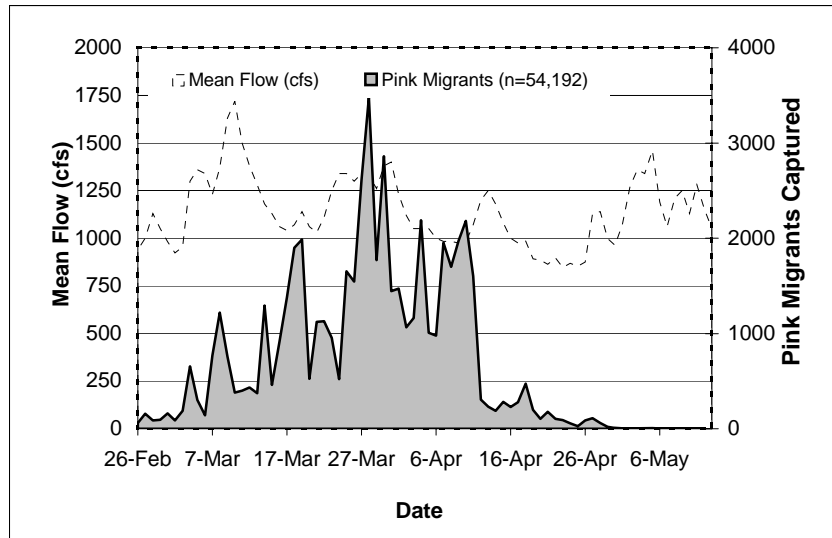
Figure 21. Daily catch of pink migrants captured in the screw trap and mean daily flows

Based upon our production estimates, 25% percent of migration occurred by March 19th, 50% by March 29th and 75% by April 6th (Figure 22). Migration was 100% complete by June 2nd.
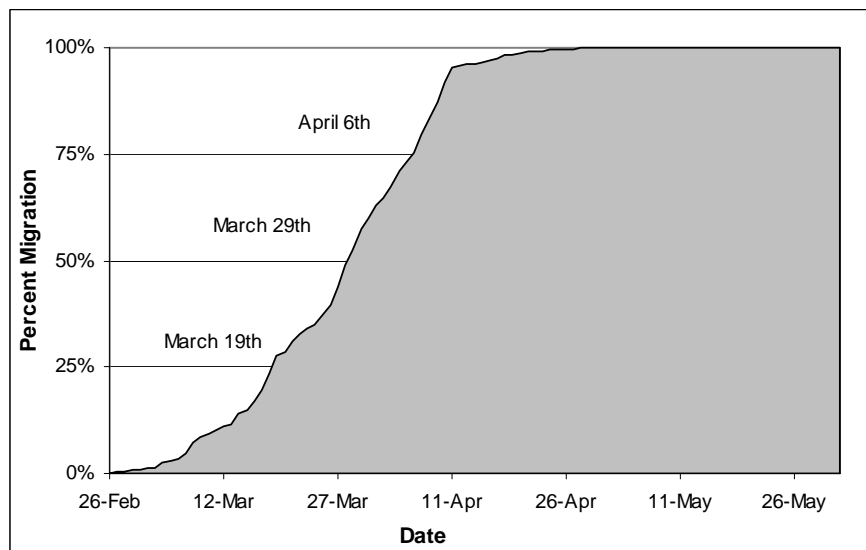
Figure 22 . Percent estimated daily migration of pink fry.

Size

The pink migrants sampled exhibited little difference in mean length between statistical weeks (Figure 23). The largest pink sampled was 44 mm during week 17 and the smallest was 21mm during week 13 (Appendix D4).
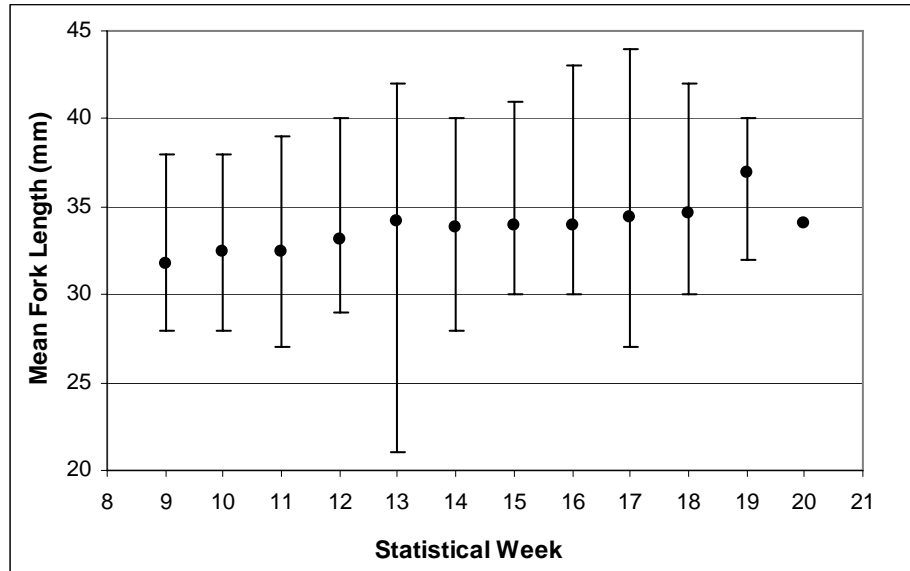
Figure 23 . Mean weekly fork length and size range of pinks captured in the screw trap.

Capture Efficiency

Of the 31 mark-recapture tests completed, we used 26 to estimate capture efficiency of the trap. Four of the tests were thrown out because of small sample size and one was thrown out because the recapture rate was zero. We found no difference between these 26 mark-recapture tests, therefore capture efficiency was combined by statistical week. There was no significant difference between combined weekly capture efficiencies for pink salmon, P=0.481 (Figure 24). However, weekly capture efficiencies were used in an attempt to reflect the influence of changing environmental conditions. A total of 6,753 pinks were released during mark recapture trials. Numbers released varied between statistical weeks. Weekly capture efficiency ranged from 2.36% to 3.68% (Appendix B4).
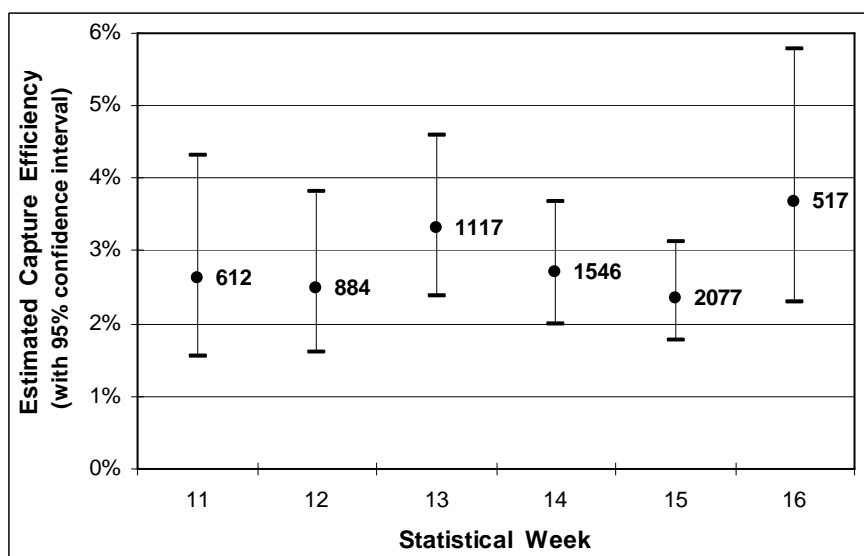
Figure 24. Estimated capture efficiency of combined weekly mark-recapture tests for pink fry with 95% confidence intervals. Labels indicate the number of pinks released per week.
``

We found no correlation between mean daily stream flows on the lower Puyallup River and capture efficiency of the trap in catching pink fry, r^2=0.0053 (Figure 25). We attribute this to the minimal variation in flows on the Puyallup during pink migration season.
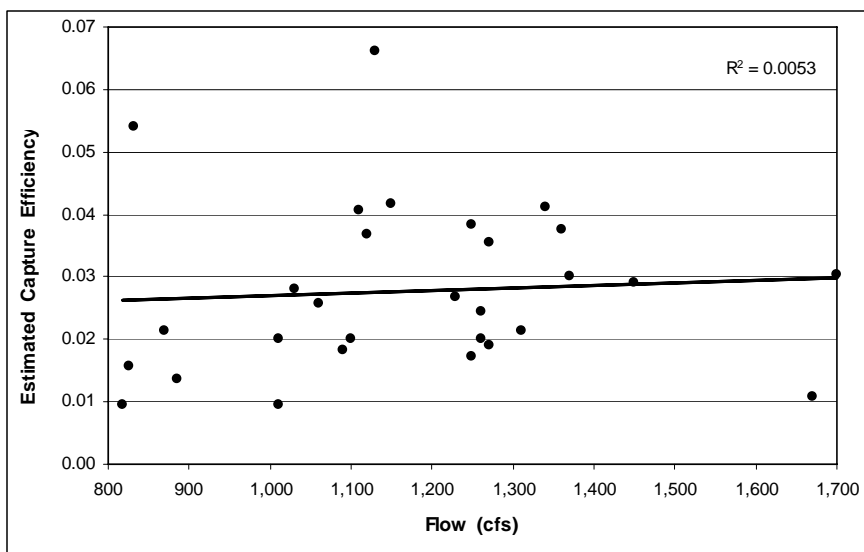
Figure 25 . Linear regression of estimated capture efficiency and flow for pink fry.

Production Estimate

Pink production estimates were based on combined mean weekly capture efficiency tests completed for statistical weeks 11 through 16. Our estimates yielded an outmigrating population of 1,988,441 pink migrants passing the screw trap in 2004 (Appendix C5).

Steelhead

A total of 39 unmarked steelhead were caught in the smolt trap (Appendix E). The first steelhead was caught on April 7th and the last on July 22nd. A peak of six unmarked steelhead occurred on May 12th. Because of the Voights Creek Hatchery steelhead program scales were taken from steelhead captured in the trap in an attempt to differentiate wild steelhead from hatchery steelhead. Age data from scale samples will be examined at a later date.

No capture efficiency tests were completed for steelhead due to the difficulty of obtaining and marking steelhead and error associated with tests of large mobile fish. However a total capture percentage from Voights Creek Hatchery was completed (Table 8.).

Table 8. Capture Percentage of Marked Steelhead from Voights Creek Hatchery Puyallup River 2004

Mark Type	Date		Number Released	Number Captured	Capture Percentage
	Start	End			
AD (Voights)[*]	4-Apr	30-Apr	231,859	191	0.08%

* = Data gathered from Pacific States Marine Fisheries Commission

ASSUMPTIONS

Catch
Catch recorded during morning and evening checks reflects the fish migrating during night and day periods, respectively. Catch per unit effort data was split by night and day migration periods.

Catch Expansion
Our data represents actual and observed samples. Numbers were not expanded, with the exception of a four-day period (88 hours) during a high flow event when the trap was not fished. During this period the catch rates for May 30th and May 31st were applied to estimate the number of unmarked chinook missed. Catch rates from May 25th were used to estimate the number of unmarked and hatchery coho missed.
- The entire emigration season for all species was sampled (February 26th to August 11th). Complete migration curves were generated for chinook, coho, pink and chum.
- The trap was fished twenty-four hours a day, seven days a week with the exception of 88 hours between May 26th and May 30th.
- We underestimated the number of fish potentially missed during the period between May 26th and May 30th.

Trap Efficiency
- All marked fish are identified and recorded.
- The number of marked fish passing the trap is known. Survival from release site to trap is 100%.
- Release strata are contained within the measured period (ie: marked fish pass the trap within a week and have no chance of being counted in the following week's release group).
- All fish released have an equal chance of being captured regardless of the amount of light during release.

Chinook
- Marked hatchery chinook are captured at the same rate as wild chinook.
- Chinook capture rate in the trap is a function of turbidity. Daily trap efficiency was calculated based on secchi depth through a power curve conversion where
$$[\text{Capture Efficiency} = \text{Secchi Depth(cm)}^{-1.074053}]$$

Chum
- Marked hatchery chum and marked wild chum are not captured at the same rate. Only wild chum mark-recapture tests were used to estimate trap efficiency.
- Environmental conditions (ie flow and turbidity) were not significant factors influencing trap efficiency during the chum migration period; there was no significant difference between individual wild chum mark-recapture trials ($P=067$). An average capture efficiency of all wild chum mark-recapture trials was used for the entire migration period.

Pink
- There was not a significant difference between pink mark-recapture trials (*P*=0.481). However in an attempt to reflect environment variables on trap efficiency more effectively, capture efficiencies were calculated by statistical week.

Turbidity
- Ambient light at each secchi measurement remained similar throughout the sampling period, regardless of the time of day.
- Average secchi readings are representative of actual turbidity

CONCLUSIONS AND RECOMMENDATIONS

Turbidity and Flow

Although there is no strong evidence that flow effects turbidity, a large-scale shift in turbidity and flow exists during the juvenile migration period of some salmonids. Since we know glacial melting is a seasonal phenomenon in the Puyallup River system, the large scale shift in turbidity is a result of glacial melt and was reported as so in our report. The importance of other environmental factors such as, air temperature and freezing levels at glacial elevations should be investigated since these factors may dictate the timing of migration and ultimately the life history patterns of juvenile salmonids. Turbidity should continue to be measured by secchi depth at each trap check and each capture efficiency test. NTUs should also be taken for capture efficiency tests in order to ensure accurate turbidity results.

Catch and Migration Timing

Using smolt trap catches to illustrate migration timing does not take into account the influence of a dynamic river system on the capture efficiency of the screw trap. We found a difference between the migration timing of juvenile chinook using screw trap catches as opposed to daily production estimates. Due to the increase of capture efficiency of the screw trap in turbid environments we believe the best way to quantify migration is to use daily estimated production because it normalizes all catch days to the degree of turbidity. Evaluation of timing and numbers of out-migrating fish using estimated daily production should continue in future years.

Trap Efficiency and Production Estimates

Chinook
When tested for difference among glacial and non-glacial periods, day and night capture efficiency tests showed no difference during non-glacial periods (non-turbid environment), yet day/night capture efficiencies were different among glacial periods (turbid environment). This suggests that hatchery fish, and presumably unmarked (wild) fish, do not use the night hours as cover when migrating in non-turbid environments but do in turbid environments. This is counter-intuitive to what we expected to see and contradicts our finding that more unmarked (wild) fish were captured at night than day, for both glacial and non-glacial periods. However, as suggested earlier, the difference in day and night capture efficiency tests during glacial and non-glacial periods may not be entirely correct due to the influence of size of fish and turbidity at time of release, and low numbers of release groups among the time period strata. Further investigation of the influence of turbidity on diel migration should be conducted by increasing the number of capture efficiency tests during each time period strata (glacial, non-glacial, day and night). If there are significant differences in night and day migration patterns for glacial

and non-glacial periods, methods for daily production estimates may need to be re-evaluated to fit environmental conditions.

Coho
More capture efficiency experiments need to be completed in order to estimate production for unmarked (wild) coho. With this information accurate data and conclusions about migration timing, total production, freshwater survival and in-river mortality can be generated. Increasing the amount of holding space on the screw trap for marked fish and/or using fish from directly from Voights Creek Hatchery for mark recapture tests would ameliorate this problem.

Chum
We were unable to find a relationship between capture efficiency and flow, capture efficiency and turbidity, or between day and night capture efficiency tests. The relationship between capture efficiency of chum migrants and environmental variables should be further investigated by completing mark-recapture tests at wide-ranging stream flows and turbidity conditions where possible. In the future, we hope to quantify a relationship between capture efficiency of chum and an environmental variable.

We found a significant difference between wild and hatchery chum releases this season. Further, hatchery fish were captured at higher efficiencies than their wild counter parts. If this finding is true for other species of salmonids, then the likelihood of bias for the chinook capture efficiencies which are generated using hatchery fish is likely. Future analysis using the difference in wild versus hatchery chum capture efficiencies could be applied to chinook capture efficiency methodologies to improve production estimates.

Pink
We released 6,753 pink fry during mark recapture tests, therefore we feel confident in our estimated capture efficiencies for this season. We were not able to draw a predictive relationship between estimated capture efficiency and environmental variables. Mark recapture tests should continue in the future with high frequency and during variable flows and turbidity where possible.

Freshwater Survival

Hatchery In-River Mortality
The difference in estimated mortality rates between Ad and Ad/CWT chinook mark groups is considerable. The Ad marked group includes Cowskull acclimation pond fish, and the Ad/CWT mark group does not. Increased mortality of the Ad marked could be a reflection of increased migration length from the acclimation ponds, but without a unique identification mark on acclimation pond fish we cannot accurately compare mortality between mark groups.

Additionally, the coho mark groups comprised mostly of acclimation pond fish exhibited a lower capture percentage than the mark groups comprised only of Voights Creek coho. Evaluation of smolt survival from the upper watershed through the Electron diversion

dam to the smolt trap should be evaluated more thoroughly to understand the effects of this migration route. Chinook and coho sub-groups with distinct marks, such as PIT tags, could be released from the acclimation ponds in order to specifically quantify survival of smolts from the upper watershed to the lower river.

<u>Unmarked Chinook</u>
The estimated freshwater survival of 3.31% seems to be lower than other systems throughout the Puget Sound area. Because we missed a portion of the migration period during high flows, our production estimates may have underestimated the actual migrating chinook population, affecting the estimated freshwater survival. Additionally, our production estimates are potentially biased since we used hatchery chinook rather than wild chinook to estimate capture efficiency. Freshwater survival for following years should be completed in order to fully understand this year's estimate.

Mortality

No mortalities on wild chinook, coho, steelhead, or cutthroat smolts occurred during screw trap operation. However, screw trap mortalities did include: 25 hatchery (Ad) chinook, 7 hatchery (Ad) coho, 1 hatchery steelhead, 900 wild pinks and 47 wild chum.

Measures were taken to reduce predation on pink and chum fry by coho smolts through the inclusion of artificial, protective habitat, structures in the live box. However, teeth marks and evidence of regurgitation was still observed on pink and chum fry carcasses. Different structures should be tested to find the best possible way to reduce and prevent pink and chum mortalities within the live box.

Incidental Catch

In addition to the focus species, we also caught 2 wild age 1+ chinook, 9 cutthroat trout, 1 trout fry and 1 bull trout and 158 coho (0+) fry. Non-salmonid species caught in the screw trap included brook lamprey, pacific lamprey, sculpin, dace, sticklebacks, sunfish, and pumpkinseeds.

INTERANNUAL RESULTS AND DISCUSSION

Each season, the trap was continually fished 24 hours a day, seven days a week, except for a few days each year when the trap was pulled due to high flows or for maintenance. The trap was pulled on the following days of each year:

- 2004, May 25th – May 29th
- 2003, March 12th – 15th
- 2002, May 31st and June 29th
- 2001, June 12th and 13th, 28th and 29th
- 2000, May 20th – May 22nd, June 6th and 24th, Sept. 2nd – 4th, 8th – 11th and 15th – 18th

In addition, the sample period varied from year to year and is as follows:

- 2004, Feb. 26th – Aug. 11th
- 2003, March 4th – Aug. 15th
- 2002, May 6th – Sept. 20th
- 2001, March 27th – Sept. 30th
- 2000, Feb. 15th – Sept. 21st

Chinook Catch and Migration Timing

Catch
Over the last five years the screw trap has been operated considerable differences in total unmarked chinook catch have been reported: 1255, 2481, 981, 1548 and 795, for 2000-2004 respectively (Appendix E1). This variation could be due to changes in chinook production, trap efficiency and sample period. Unfortunately, statistically accurate trap efficiency estimates are not available for past years; therefore it is difficult to quantify a relationship between years. The full migration period for chinook was not sampled in 2001 and 2002; therefore, a portion of the run was most likely missed. The largest catch year of 2,481 chinook migrants occurred in 2001. In 2004 we also missed a portion of the chinook run as the trap was not fishing during a high flow event. In future years, sampling should occur from late February to late August and include sampling during some high flow events. This would allow for more accurate catch totals.

Migration Timing
Although the trap sample period was different for each year, higher daily chinook catches were recorded during late May to early June and minimal catch during mid February and mid September. In general, peak catches of unmarked chinook coincided with the release of hatchery chinook from Voights Creek Hatchery and tribal acclimation ponds. Hatchery chinook releases from Voights Creek usually began during the last week of

April, with fish being forced out on the last day of May, and most hatchery chinook released from tribal acclimation ponds occured during mid June.

In 2002 and 2003, peak catches did not occur around high flow events but the high flow event of the migration period occurred much earlier than other years. Further, the general migration peak remained similar for each year (late May to early June). Although evidence is not strong, fish seem to migrate at a similar time each year regardless of the peak flow event, whether or not this is an artifact of unmarked hatchery fish being counted as unmarked (wild) fish or actual migration/life history timing remains to be seen.

It is difficult to determine if releases of hatchery chinook affect wild chinook migration, due to the apparent overlap between migration of wild fish and releases of hatchery fish. Without biological analysis of fish for origin, definitive identification of wild fish versus unmarked hatchery fish is difficult. In the future, DNA samples obtained by taking a small piece of the anal or caudal fin should be taken in order to estimate the contribution of unmarked hatchery fish to our chinook catches and production estimates.

Chinook Size

To evaluate the effects of hatchery migrants and pink run years on juvenile chinook fork length, annual mean as well as maximum and minimum fork length data was produced for all years except 2000 (Appendix E3). In 2001 and 2002 the smolt trap was not operating until week 15 and 19, respectively. Mean fork length was the highest in 2004 with several weeks data showing mean fork length above 90mm and lowest in 2002 with no weeks reaching 85mm or greater. There does not appear to be a decrease in size of chinook migrants over the past several years, or during pink years (2002 and 2004).

Steelhead Catch and Migration Timing

Catch
Wild steelhead catch has decreased and become more sporadic over the years, with a drastic drop in numbers over the last two years. Catch totals were 539, 156, 250, 72, and 39 respectively for 2000-2004 (Appendix E2). Steelhead migration is difficult to quantify based upon smolt trap catches as they are larger, mobile fish and are thought to exhibit trap avoidance. Even so, based upon catch an obvious decline in the migrating population has occurred.

Migration Timing
For all years, the earliest steelhead was caught at the beginning of March (2000 and 2004), and the last was caught at the end of July, 2004, with a majority of fish migrating between late April and late May. High daily steelhead catches occurred earlier than chinook, during late April to mid May, with most catches recorded after April 30th. Coincidentally, April 30th is the forced release date for hatchery steelhead from Voights Creek hatchery. Although steelhead are adipose fin clipped before release, the increase

of wild steelhead catch at the end of April may be a reflection of miss-clipped steelhead from Voights Creek Hatchery. This year, scale data was taken from smolts in order to determine origin of wild steelhead. Future collection of scale data will help monitor the actual migrating juvenile population of steelhead.

Species Composition

Hatchery versus Wild
Hatchery fish generally comprise the majority of screw trap catches, with the exception of 2004 when we caught 54,192 pinks, equaling 59% of our total catch. Otherwise, the largest percent of wild fish caught during any year was a 6% catch of unmarked coho in 2002 (Appendix E4). Wild chinook have comprised between 1% and 4% of our total catch from 2000 to 2004.

During five years of smolt trap operation, marked chinook consistently comprised the majority of the catch ranging from 30% to 76% (Appendix E4). In 2004, when marked chinook accounted for only 30% of the total catch, the peak of hatchery chinook migration was missed due to a high flow event. Marked coho generally fill the next largest catch component ranging between 7% and 43% of the total catch.

Wild Catches
Over the years, chum have accounted for nearly half of our catch totals of wild fish. Percent catch ranged from 32% to 48%, with the exception of 2004 when pinks comprised 94% of the wild catches and chum made up only 4% of the catch (Appendix E5). Pink catch increased from 26% of wild catches in 2000 to 94% of wild catches in 2004. We do not have data for the 2002 pink catch as screw trap operation did not begin until May 31st . Unmarked chinook catch ranged from 1% to 32% of the total catch. However the chinook catch of 1% occurred in 2004 when the pink catch was high.

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